

Systematic literature review on the implementation of the Six Sigma approach in education

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ABSTRACT

The quality of teaching and pedagogical practices of teachers is a global issue in education. The success of Six Sigma in several industries stimulates its potential to be applied in the field of education. However, discussions related to Six Sigma development in systematic education are still very limited. Therefore, this systematic literature study was conducted to synthesize empirical data on the implementation of the Six Sigma approach in education. This study focuses on two main objectives, namely to identify the trends in the implementation of the Six Sigma approach in education based on national and year tendencies as well as to identify research sampling trends and the focus of the field of study. The Web of Science and Scopus databases have been used based on the preferred reporting items for systematic reviews and meta-analyses (PRISMA). The findings of systematic literature articles showed that India is the most dominant country conducting Six Sigma studies in education. Furthermore, related studies were conducted the most in 2017. In addition, the research samples are also more focused on the context of higher education institutions. These findings help improve the general understanding of Six Sigma in education to improve the quality of teachers in schools further.

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1. INTRODUCTION

Quality education is the cornerstone of a nation's development [1]. Therefore, the importance of quality in education cannot be ignored. The issue of meeting the needs of customers not only exists in the industry or services sector but also in educational institutions [2], [3]. The concept of quality is important in educational institutions to ensure that the education system improves since the field of education is constantly evolving and reformed in various ways [4], [5]. Hence, Akareem and Hossain [6] argued that a quality education system is needed to weather the era of globalization since the system is capable of producing a creative, skilled, competitive, and resilient workforce in order to address the country's challenges and globalization currents.

Most international educational organizations around the world such as Australia, Canada, Singapore, India, Switzerland, the United States, and the United Kingdom have implemented the concept of quality in the education system. Total quality management (TQM) or the TQM methodology such as Six Sigma, Kaizen, continuous quality improvement (CQI), and quality management systems such as International Organisation for Standardisation (ISO) 9001 are implemented to improve quality in education [7]–[10]. Furthermore, all these countries have become increasingly aware of the quality aspect and have also shown interest in implementing the concept of quality after attending the United Nations Educational Scientific and Cultural Organisation (UNESCO) World Education Forum in Dakar in 2000, which highlighted the need for improving quality education [11].

Nonetheless, the challenge of improving the quality of educators is a global issue that has always been a concern for policymakers in each country. In order to ensure a quality education system, all parties should play their respective roles effectively in educational institutions [12]. Teachers are the main driving force behind the transformation process and the provision of quality education [13]. Quality teachers can produce quality students and this becomes the main factor that determines the success of students [14]. The higher the quality of a teacher, the higher the effectiveness in carrying out work, particularly in ensuring that the students receive the highest quality of education [15]. Therefore, the quality of teachers determines the success of students and this has indeed become the main objective of education reform in most countries [16].

2. LITERATURE REVIEW

Six Sigma refers to the continuous improvement methodology in TQM [17], [18]. According to Sharma [19], Six Sigma is a systematic approach that focuses on improving quality and performance, particularly in the process to achieve customer satisfaction. Sirshar *et al.* [20] also found Six Sigma a data-driven continuous improvement strategy to improve the quality of revenue by reducing defects in the manufacturing process of a product or service. Six Sigma is considered a goal to be achieved to reduce output defects when the process is carried out [21]. The sigma symbol (σ) refers to standard deviation, which originated from Greece and is often used in mathematics [22], [23]. Statistically, Six Sigma is defined as a unit of measurement that can reduce a problem to 3.4 defects per million opportunities [24], [25]. In other words, to reach the level of Six Sigma, the probability process of producing an error (defect) is only 3.4 out of 1,000,000 units, and 99.99966% of the result is perfect [26]. In essence, this means that the process is highly accurate and that it can make six standard deviations between the average achievement and the specification limit set by the customer [25]. Six Sigma is graphically represented as a bell-shaped curve or normal distribution [27]. Technically, the sigma value is the efficiency of the process capability; the higher the Sigma value, the better the process is [18]. Thus, to achieve the Six Sigma level, the Six Sigma methodology is used to ensure that an organization can achieve optimal customer satisfaction [18], [28].

The evolutionary development of Six Sigma began in the mid-1980s and was developed at Motorola by Bill Smith who was an engineer at Motorola [22], [29], [30]. Moreover, the Six Sigma approach received the full support of Motorola CEO, Bob Galvin, who also agreed that the Six Sigma approach is a strategy for improving processes and quality control at his company [31], [32]. As a result, in 1988, Motorola received its first Malcolm Baldrige National Quality Award [22], [33]. The outstanding success achieved by Motorola has attracted the interest of many large companies to use Six Sigma such as Allied Signal, Texas Instruments Defense Group, IBM, and Digital Electronics. The adoption of Six Sigma has helped these companies improve the quality of products and services by improvising the optimal output production process through waste reduction [33]. Six Sigma then continued to grow in popularity worldwide, especially after Jack Welch used it as a business strategy at General Electric (GE) in 1995 [34], [35]. Jack Welch, who was the person in charge of GE, made a huge profit by utilizing Six Sigma [26]. Six Sigma has increasingly begun to be adopted by many sectors such as healthcare, financial institutions, the construction industry, hospitality, and tourism, as well as government organizations [36].

Six Sigma's success in the industry and services sector has attracted scholars to apply the Six Sigma approach in the field of education [22], [37]. Six Sigma has been used in the education sector since 2000 and has been successfully adopted in most areas of education [38]. Among the areas that can be improved by applying the Six Sigma approach are curriculum, infrastructure, student learning performance, academic achievement, learning community, as well as teaching and learning [36]. The results of the literature show that Six Sigma is an effective strategy to improve quality in educational institutions [39]–[41]. However, the compilation of Six Sigma studies in education is scarcely discussed. Studies have been conducted across only three main areas of education: management, teaching and learning, and student development. In fact, the research samples were more focused on the context of higher education institutions (HEIs). A systematic literature review is important to identify the extent of Six Sigma's effectiveness as a continuous improvement strategy in education. In addition, the findings can help other researchers conduct further studies in the future. Hence, this systematic literature review was conducted for the following purposes: i) to identify the trends in the implementation of the Six Sigma approach in education based on national and year tendencies; ii) to identify research sampling trends and the focus of Six Sigma implementation studies in education.

3. RESEARCH METHOD

Ting and Matore [42] stated that a systematic literature review (SLR) refers to studies that are conducted to answer research questions by identifying, analyzing, formulating, and critically assessing the contents to be studied in the relevant past studies. The flow diagram of Preferred Reporting Items for systematic reviews and meta-analyses (PRISMA) guideline by Moher *et al.* [43] was used in the selection of relevant

articles. PRISMA is also a quality systematic literature review guideline since its relatively rigorous and detailed process involves large quantities of data [44].

In addition, Okoli [45] identified the advantages of using the PRISMA method in the field of social sciences where the works obtained were from quality data sources and are recognized by all researchers to explain the research limitations with the help of keywords; moreover, this guideline also helps save authors' time just in case the authors are wondering if their literature review has been enough. Jamaludin *et al.* [46] also agreed that the PRISMA method can help researchers determine the necessary studies based on the research questions. There are four steps in the PRISMA flowchart to determine which study is suitable for the researcher's needs, beginning with the process of identification, screening, eligibility, and inclusion [47], [48].

3.1. Article search strategy

Article search for SLR is based on two types of academic databases, namely Web of Science (WoS) and Scopus. These databases were used in this study because they include all journal articles from a variety of different links. Gusenbauer and Haddaway [49] stated that the selection of the two base resources includes "search engines," which assist in obtaining appropriate and quality studies for systematic research. The search was also implemented with the keyword settings "Six Sigma" and "Six Sigma in Education" in WoS and Scopus. Table 1 shows the keywords used in the article selection process.

Table 1. Article search for SLR

Database	Keyword
Web of Science	TI= (SIX SIGMA IN EDUCATION)
Scopus	TITLE-ABS-KEY (six AND sigma AND in AND education)

3.2. Article selection criteria

To obtain accurate and appropriate articles in accordance with the research questions, several steps have been taken to filter all the articles obtained as shown in Figure 1. The first screening process is based on several acceptance and rejection criteria, respectively. The five steps of criteria setting include the year of publication, type of reference material, language, methodology, and journal article's field of study. These steps assure a journal article that discusses the implementation of Six Sigma in education for SLR purposes.

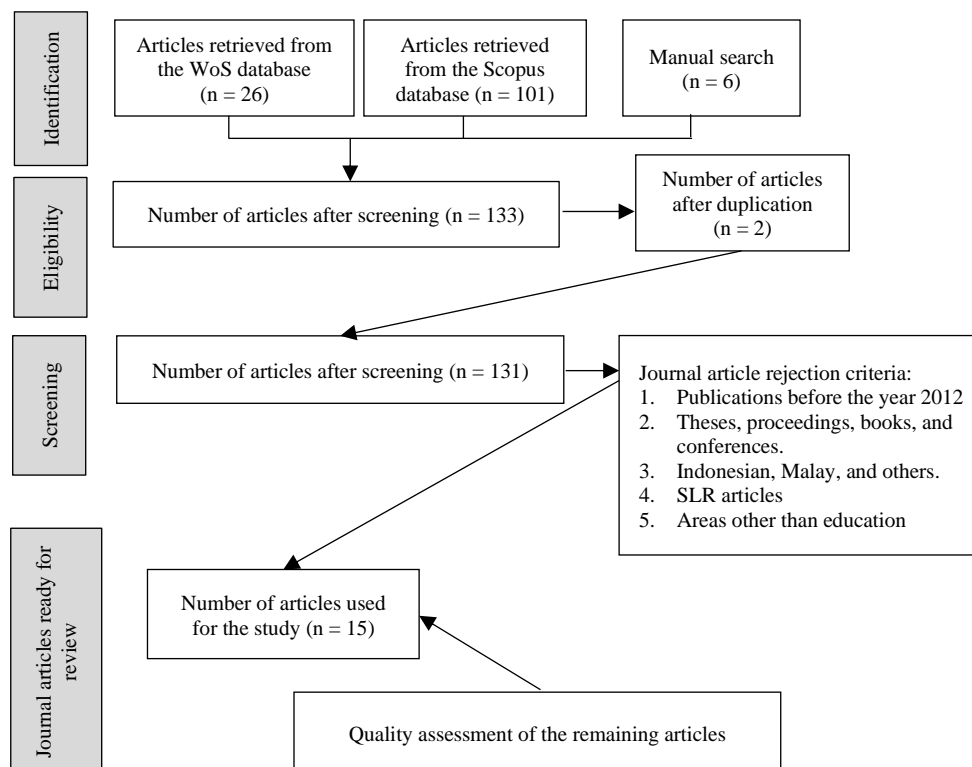


Figure 1. Article selection process flow [43]

The first step entails the publication year of the articles, particularly the latest 10 years from 2012 to 2022. The main reason for selecting this setting is that the implementation of the Six Sigma approach is deemed relatively new in the field of education; therefore, the 10-year range is used to limit searches. The second step entails the removal of articles having the same findings or recurrent articles, even from different databases. In addition, only journal articles were selected, while SLR articles, books, proceedings, theses, and conferences were excluded from this study. In the third step, all the selected articles are in English, while in the fourth step, the analysis was carried out through a full and in-depth reading of the selected articles. The methodology chosen in each journal article includes quantitative, qualitative, and mixed methods. In the fifth step, the areas of study selected include the implementation of the Six Sigma approach at school and higher education levels. Table 2 shows the criteria for the acceptance and rejection of journal articles for this study.

Table 2. Article acceptance and rejection criteria

Criterion	Acceptance	Rejection
Year of publication	Publications from 2012-2022	Publications before the year 2012
Type of reference material	Journal articles	Theses, proceedings, books, and conferences
Language	English	Indonesian, Malay, and others
Methodology	Quantitative, qualitative, mixed method.	Systematic literature review
Field of study	Education	Others

3.3. Article selection process

WoS and Scopus databases as well as manual search have been used in this study to find, identify, and determine the suitability of articles in order to answer the research questions. Shaffril *et al.* [50] suggested a manual search method for selecting articles through “handpicking”. Since Google is a reliable search engine and it contains articles about Six Sigma in Education, this method was, therefore, used in this study. Accordingly, the title of each article, abstract, and main content were reviewed to ensure that the article is appropriate and meets the established criteria. Next, the selected articles were filtered before being processed to the subsequent level. Figure 1 shows the PRISMA flow diagram [43], which explains the process of searching and screening articles to serve as analytical data. Overall, a total of 143 articles were identified from both databases.

3.4. Data collection and analysis process

After going through each article selection process, only 15 out of 143 articles were selected for this study. Additionally, the analyzed articles have undergone a process of article acceptance and article rejection based on the established criteria. Table 3 shows a list of selected journal articles with the authors' names, publication years, and research titles. The results of the analysis are presented using data representations such as bar graphs and tables.

Table 3. List of articles analyzed in SLR

No.	Article	Year	Country	Article title
1.	[4]	2020	India	Implementation of DMAIC methodology of Six Sigma in vocational education and training for quality
2.	[5]	2020	Mexico	Measuring critical success factors for Six Sigma in HEIs: development and validation of a surveying instrument
3.	[22]	2017	United States	Six Sigma in Education
4.	[24]	2019	Kuwait	Using 6 Sigma to improve outcomes of higher education institutes
5.	[30]	2014	Bangladesh	Applying Six Sigma in higher education quality improvement
6.	[36]	2016	Jordan	Leveraging Six Sigma tools and methodology to improve student English language performance at elementary school
7.	[38]	2022	India	Analytical investigation of higher education quality improvement by using Six Sigma approach
8.	[51]	2022	China	Application of Six Sigma management-based teaching method in financial management course online teaching
9.	[52]	2021	Jordan	Six Sigma Application for Raising Student Academic Achievement
10.	[53]	2017	India	Measuring academic quality: a three-dimensional approach for internal audit using DMAIC
11.	[54]	2017	United States	Impacting Big Data analytics in higher education through Six Sigma techniques
12.	[55]	2015	Saudi Arabia	Appraisal of students experience survey (SES) as a measure to manage the quality of higher education in the Kingdom of Saudi Arabia: An institutional study using Six Sigma model
13.	[56]	2014	India	Quality excellence in higher education system through Six Sigma: student team engagement model
14.	[57]	2013	India	Appraisal of student rating as a measure to manage the quality of higher education in India: An institutional study using Six Sigma model approach
15.	[58]	2012	Taiwan	Enhancing teaching effectiveness by using the Six Sigma DMAIC model

4. RESULTS AND DISCUSSION

4.1. First research objective: to identify the trends in the implementation of the Six Sigma approach in education based on national and year tendencies

Figure 2 shows the tendencies of the number of Six Sigma publications in education in several countries around the world. Based on the diagram, a total of nine countries have published articles on Six Sigma in the context of education. India was the most dominant country and contributed five articles (33.33%), followed by Jordan and the United States representing 13.33% of the total articles, as well as Saudi Arabia, Kuwait, Bangladesh, China, Taiwan, and Mexico, which accounted for 6.67% of articles, respectively.

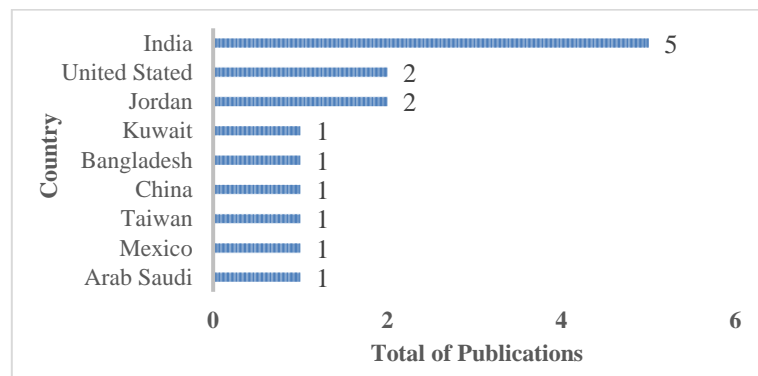


Figure 2. Tendencies of states in article publications

The findings also showed that Six Sigma in education has never been examined in the context of education in Malaysia. The analysis results showed that India dominated the publication of Six Sigma articles in the field of education [4], [38], [53], [56], [57]. Abdulla and Kavilal [38] stated that the National Board of Accreditation India (NBA) suggests using the Six Sigma approach as one way to assess quality criteria in education in India. This is because, by 2030, India is expected to emerge as a world economic power where quality education must be prepared [59].

Additionally, the United States contributed two publications of articles [22], [54]. The same goes for Jordan, who contributed two publications of articles from the same author [36], [52]. The first study conducted by Arafah focused on administration improvements in schools, while the second study was aimed at improving student performance in academia using the Six Sigma approach. On the contrary, other countries have only published one article, such as Mexico [5], Kuwait [24], Bangladesh [30], China [51], Saudi Arabia [55], and Taiwan [58]. Figure 3 shows the tendencies of the publication year of Six Sigma articles in education. Evidently, in the past ten years from 2012 to 2022, not many Six Sigma articles in education were published. As a matter of fact, only 15 articles were published throughout this period and the number of publications during this period was consistent. Interestingly, there was also an increase in the publication of related articles in 2017; however, no studies on Six Sigma in education were conducted in 2018.

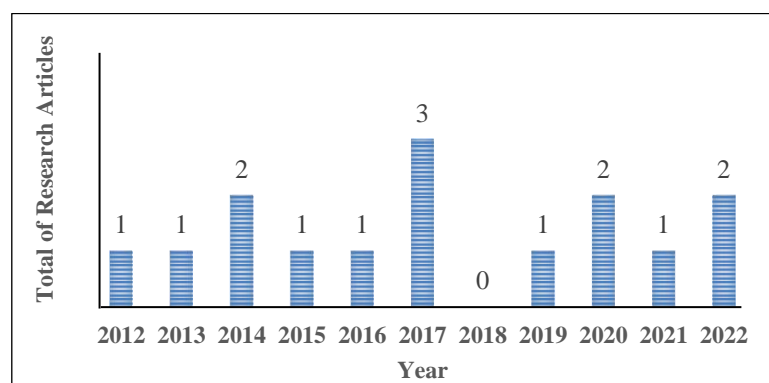


Figure 3. Article publications from 2012-2022

4.2. Second research objective: to identify research sampling trends and the focus of Six Sigma implementation studies in education

Table 4 shows the analysis of respondents and the focus on the implementation of Six Sigma in education in each of the articles selected. The analysis of the survey respondents showed that only three articles with 20% carried out Six Sigma studies at the school level, i.e., two in primary school [22], [36] and one in secondary school [52]. Meanwhile, the remaining 12 articles with 80% of Six Sigma studies in education are focused more on HEIs. Previous researchers [60], [61] suggested that HEIs should refer to Six Sigma as a strategy for improvement and success in maintaining students' academic quality at a high standard. Similarly, Cano *et al.* [41] also argued that Six Sigma is among the good quality improvement methods for the improvement process in the field of education.

The analysis results of the 15 selected articles showed that the Six Sigma approach to education focuses on three areas, namely management, teaching and learning, as well as student development. A total of five published articles are focused on management aspects [4], [5], [22], [38], [53]. The analysis results also showed that the Six Sigma approach has identified the cause of defects that occurred in technical education in India [38]. In addition, MacIel-Monteon *et al.* [5] evidenced that the Six Sigma approach has assisted management at the university in identifying potential areas for improvement as well as enhancing the quality of management. Likewise, Nuresa *et al.* [31] also stated that the main concept of Six Sigma is focused on improving a process to obtain good and optimal results.

Meanwhile, a total of five published articles are focused on the aspect of student development, particularly in improving students' academic achievement [24], [30], [36], [52], [54]. This is in line with the previous findings reported [62]–[64], where one of the key concepts of Six Sigma is to satisfy or meet the needs of customers. In an educational institution, each instructor should focus on students who are clients of the services provided at schools or any educational institution [65]. Therefore, instructors should always plan the routines to be carried out daily to ensure that the best quality of teaching is provided to students [30].

Based on the analysis results, there are still fewer studies on the Six Sigma approach to measure and evaluate the teaching quality of teachers. In fact, the published articles using the Six Sigma approach to improve the quality of teaching and learning are only focused on lecturers at HEIs [51], [54]–[57]. However, Yu *et al.* [58] argued that the teaching quality of teachers in schools is also important and should be emphasized to ensure that the teaching and learning process runs effectively and achieves the goals set in quality education. This is because the Six Sigma approach can help teachers identify the root causes of problems faced in teaching and learning as well as offer continuous improvement methods to help the teachers improve the quality of teaching. Besides, one of the Six Sigma concepts according to previous study [4] is to eliminate the cause of defects; they also stated that Six Sigma is an approach used when the cause of the problem is not found to improve the critical process. Therefore, the application of Six Sigma in schools to improve the teaching quality of teachers is desirable.

Table 4. Research focus and stages of research samples

No.	Articles	Research samples			Teaching and learning	Research focus	
		Primary school	Secondary school	HEIs		Student development	Management
1.	[4]			√			√
2.	[5]			√			√
3.	[22]	√					√
4.	[24]			√		√	
5.	[30]			√		√	
6.	[36]	√				√	
7.	[38]			√			√
8.	[51]			√	√		
9.	[52]		√			√	
10.	[53]			√			√
11.	[54]			√	√		
12.	[55]			√	√		
13.	[56]			√	√		
14.	[57]			√	√		
15.	[58]			√		√	
Total		2	1	12	5	5	5

5. CONCLUSION

Based on SLR, not many Six Sigma articles in education have been published, especially in Malaysia over a ten-year period from 2012 to 2022. An interesting finding that can be shared is that Six Sigma in the context of education in Malaysia is very limited and has never been examined. India dominates the publication of Six Sigma articles in the field of education compared to other countries. Past studies have also shown that sampling trends are more popular in HEIs. The Six Sigma approach in education focuses on three areas, namely management, teaching, and learning, as well as student development. This review clearly shows that there are still fewer studies on the use of the Six Sigma approach to measure and evaluate the teaching quality of teachers in Malaysia. In fact, the existing articles using the Six Sigma approach are limited to measuring the improvement of the teaching and learning quality of lecturers in HEIs. The findings of the SLR can encourage the idea of expanding the potential of Six Sigma through more effective strategies to improve the quality of teachers, particularly in teaching and learning in schools. In addition, the clear theoretical contribution to the development of the Six Sigma concept in the educational context compared to the previous one dominated by engineering also has a positive impact on student development. Thus, future research is recommended in order for the relevant parties to conduct studies on the effectiveness of Six Sigma in the education sector, particularly in the Malaysian context.

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